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Browsing, Discovery and Search in Large Distributed Databases
of Complex and Scanned Documents

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13. ABSTRACT *(Maximum 200 words)*

This project aims to integrate powerful, new techniques for interactive browsing, discovery, and retrieval in very large, distributed databases of complex and scanned documents. Emphasis is placed on going beyond full-text retrieval techniques developed in the DARPA TIPSTER program to support different types of access and non-textual content. These techniques should be particularly relevant to the patent domain where it is important to find relationships between documents and where the patent or trademark may be based on a visual design. The specific tasks identified involve studying representation techniques for long documents with complex structure, browsing and discovery techniques for large text databases, image retrieval and scanned document retrieval techniques, and architectures for large, distributed databases.

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Technical and Scientific Report

Task 1: Representation Techniques for Complex Documents

Task Objectives

In this task, the goal is to extend the word-based representations that are common in retrieval systems in order to support summarization, browsing, and more effective retrieval. Specifically, we have been studying phrase-based representations and relationships between phrases in individual and groups of documents as the basis for our approach. Document structure will be used as part of the information that is used to "tag" the phrasal representation.

Technical Problems

The technical problems have to do with defining a "phrase", developing techniques for rapidly extracting them from text, comparing phrase contexts to identify significant relationships, producing summaries from these representations, extending the underlying retrieval model to be able to make effective use of phrasal representations, and using complex document structure in indexing and retrieval.

General Methodology

The general methodology for this task is to demonstrate effectiveness through user-based and collection-based experiments. As well as the PTO text databases, we will make extensive use of the TIPSTER document collection, which consists of a large number of text documents from a variety of sources, queries, and user relevance judgments for each query.

Technical Results

We have developed a new probabilistic technique for phrase extraction, based on Markov models, which requires no part-of-speech tagging or syntactic analysis. We have shown that this technique works as well as existing techniques, and reported these results in the following paper:

- Feng, F. and Croft, W.B. "Probabilistic Techniques for Phrase Extraction," submitted to Information Processing and Management Management.

- The following paper on phrase extraction which was submitted for review has been accepted:Pickens, J. and Croft, W.B. "An Exploratory Analysis of Phrases in Text Retrieval," accepted to RIAO 2000 Conference, Paris, France, April, 2000.

We continue to develop the new retrieval technique based on language models. We continue to carry out experiments to see the effects of learned language models on retrieval.

Important Findings and Conclusions

Language models are becoming an important in modern search engines.

Significant Hardware Development

None.

Special Comments

None.

Implication for Further Research

Language models may provide retrieval improvements for PTO data.

Selective incorporation of phrase operators with appropriate weights may improve retrieval on PTO queries.

Task 2: Browsing and Classification Techniques for Document Collections

Task Objectives

The goals of this task are to develop techniques for summarizing and classifying collections of documents. These techniques will be designed to support interactive browsing and text classification in environments like the PTO.

Technical Problems

The technical problems involve producing an effective summary of a group of documents, such as a retrieved set or an entire database. Both document and phrase clusters could be used as part of this process. The classification task emphasizes the ability to accurately assign predefined categories (as in the PTO classification) to new documents (patents). An additional problem is to determine when existing classifications do not match well to new documents, such as when a PTO category covers too many patents and needs to be refined.

General Methodology

Evaluation of these techniques will be done using both the TREC corpus and PTO data. For the classification task in particular, we are designing evaluation criteria with substantial input from PTO staff.

Technical Results

The results from earlier distributed retrieval research showed that collection selection is an effective method for dealing with collections that must be subdivided into smaller collections. We are, therefore, working on a multi-level classification scheme which involves dividing a database into smaller databases by class and then using collection selection to find the appropriate class. We are comparing standard classification algorithms with collection selection algorithms for the first-level classification scheme.

We are continuing work with Dataware Technologies to evaluate different approaches to classification.

In the summarization/visualization area, we have continued to develop techniques for combining ranked lists with clustering. A ranked list is a well-known technique for presenting information so that relevant documents may be found quickly. Clustering is also a well-known technique for grouping similar documents. We have improved our method of combining the two approaches and developed a better evaluation technique, providing more effective and robust results. This work is described in the following papers:

- Leuski, A. and Allan, J. "Lighthouse: Showing the Way to Relevant Information," submitted to the IEEE Symposium on Information Visualization 2000 (InfoVis 2000), Salt Lake City, Utah, October 9-10, 2000.

- Allan, J., Leuski, A., Swan, R. and Byrd, D. "Evaluating Combinations of Ranked Lists and Visualizations of Inter-document Similarity," submitted to Information Processing and Management (IPM).

- The following paper which was submitted for review has now been accepted:
- Leuski, A. and Allan, J. "Improving Interactive Retrieval by Combining Ranked List and Clustering," to appear in to RIAO 2000 Conference, Paris, France, April, 2000. The following paper on deriving Yahoo like subsumption hierarchies which was submitted for review has been accepted:Lawrie, D. and Croft, W.B. "Discovering and Comparing Hierarchies," accepted to RIAO 2000 Conference, Paris, France, April, 2000.

Important Findings and Conclusions

None.

Significant Hardware Development

None

Special Comments

None.

Implication for Further Research

These visualization and summarization techniques could enhance the user interface of a search and classification system such as that of the PTO demo. We are using the multi-level classification scheme in the demo system, and will update it to include the best performing classification approach for the first stage. We are still evaluating different approaches to classification with Dataware.

Task 3: Image Indexing and Retrieval

Task Objectives

The goal of this task is to develop similarity-based techniques for retrieving images such as trademarks, logos, and designs.

Technical Problems

The central issue is how images can be indexed to support efficient, content-based retrieval. The primary type of query in these environments is "find me things that look like this". We are developing "appearance-based" retrieval of images as well as more straightforward features such as color and texture. Filter based and frequency domain based techniques offer some potential in this area, but significant work needs to be done on making this approach efficient enough to deal with hundreds of thousands of images.

General Methodology

The evaluation of these techniques will be done in a similar way to text by developing test collections of images. Specifically, we are working to obtain large collections of trademark and design images, both from the PTO and from general sources such as the web.

Technical Results

- Our work is now focused on evaluating the demonstration system.

On closer examination, we discovered that the relevance judgments for the British trademarks were not completely reliable. We are, therefore, working on creating our own relevance judgments based on visual similarity. We are now collaborating with the University of Glasgow to obtain relevance judgements for the geometric trademarks from the British Patent Office. For this purpose, we have created a user interface. We also continue to improve the effectiveness of our trademark retrieval system.

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- We continue our work on modifying our technique for segmenting flowers from images may also be used for segmenting other objects like birds. We are now focusing on using color and edge information to segment birds from their background. This work is still ongoing..

Important Findings and Conclusions

None.

Significant Hardware Development

None

Special Comments

None.

Implications for Further Research

We continue to focus on evaluating the accuracy of our techniques using trademark testbeds from Britain and, hopefully, from the U.S. PTO. We will also continue to improve the demonstration system.

Task 4: Distributed Retrieval Architecture

Task Objectives

The goals of this task are to scale up our current methods of automatically selecting collections and merging results, and to investigate architectures that can support efficient retrieval, browsing and relevance feedback in distributed environments with terabytes of information.

Technical Problems

The current INQUERY text retrieval system uses a client-server architecture to support simultaneous retrieval from multiple collections distributed across one or more processors. A number of efficiency bottlenecks develop, however, when the size of the databases is very large. Deciding which subcollections to search can address part of the problem, but there are other problems associated with the fundamental efficiency of the processes involved and the use of distributed resources. Image indexing and retrieval tends to exacerbate these efficiency problems since the databases and indexes are considerably larger.

General Methodology

The architectures and algorithms produced in this task will be evaluated using a combination of standard performance (efficiency) measures and effectiveness measures. The efficiency tests will be done using TREC data and large PTO databases, including images, and the collection selection algorithms will be evaluated using the text subcollections of the patents.

Technical Results

We have extended our work on distributed retrieval by showing that good distributed retrieval performance can be achieved with only local, rather than collection-wide, information, as reported in the following paper:

- Powell, A., French, J., Callan J., Connell, M. Viles C. . "Measuring the Impact of Database Selection on Distributed Searching," to appear in the Proceedings of SIGIR 2000, Athens, Greece, August, 2000.

Results from other research suggest that it if large collections need to be divided into smaller collections, it is better to organize by subject. We are verifying this with PTO data and comparing four different algorithms for merging databases to determine whether different merging algorithms are optimal for different database organizations.

We have continued to explore architectural issues concerning subdivided collections in:

- Lu, Z. and McKinley, K. "Partial Collection Replication versus Caching for Information Retrieval Systems," to appear in the Proceedings of SIGIR 2000, Athens, Greece, August, 2000.

Important Findings and Conclusions

Organization by topic is likely to be better than a chronological organization. Distributed search can be more effective than centralized search if it is based on language models. Database sampling is the first practical method of discovering (or verifying) the contents of databases controlled by third parties.

Significant Hardware Development

None.

Special Comments

None

Implications for Further Research

Organizing documents by subject is likely to be more effective than organizing them by the date of the document. We will continue to evaluate performance of distributed architectures for scalable IR using the new demonstration system. Database sampling is a good practical way of discovering (or verifying) the contents of databases controlled by third parties.